HETEROCYCLES, Vol. 31, No. 10, 1990

[4 + 2]CYCLOADDITIONS OF PYRANO[3,4-b]INDOL-3-ONES WITH 1,2-BIS-ACCEPTOR SUBSTITUTED ETHENES: FIRST EVIDENCE FOR A NON-CONCERTED DIELS-ALDER STEP

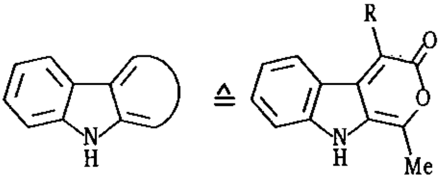
Ulf Pindur* and **Houshang Erfanian-Abdoust**

Department of Chemistry and Pharmacy, University of Mainz,
Saarstrasse 21, D-6500 Mainz 1, Federal Republic of Germany

Abstract —— The Diels-Alder reactions of pyrano[3,4-b]indol-3-ones (1) with 1,2-bis-acceptor substituted ethenes yield stable 1,2-dihydrocarbazoles and fully aromatized carbazoles. The results of stereochemical determinations in the 1,2-dihydrocarbazoles and, in one case, the occurrence of a bimolecular, diene-catalyzed dienophile isomerization provide the first evidence that a *non-concerted* [4 + 2]cycloaddition is mainly in operation. The pyrido[3,4-b]indol-3-one (11) was attacked by dienophiles only at the lactam nitrogen atom and cycloaddition did not take place.

The Diels-Alder reactivity of pyrano[3,4-b]indol-3-ones (1) and related compounds as stable, cyclic indole-2,3-quinodimethanes (I) with carbo- and hetero-dienophiles is now well established.[1-5] However, information concerning the mechanism of the crucial Diels-Alder step in the tandem reaction sequence to furnish the highly interesting carbazole derivatives is still very scarce.[3,4] For the Diels-Alder reactivity of the methyl-substituted pyrano[3,4-b]indol-3-ones (1a) and (1b) acting as 4π-systems, we have proposed a $HOMO_{diene}$-$LUMO_{dienophile}$ controlled mechanism on the basis of MNDO calculations which rationalizes the experimental results obtained so far.[3,4] In general, for further experimental investigations of the mechanisms of Diels-Alder reactions, analytically pure E- and Z-dienophile reagents have frequently been employed as stereochemical probes.[6,7]

In the present investigations, we have now been able to show for the first time in pyranoindol-3-one chemistry that a non-concerted [4 + 2]cycloaddition should be involved in spite of the energetically optimal frontier orbital situation.[3,4] This conclusion was based on analyses of product stereochemistries and on the *E*/*Z*-isomerization of one of the tested dienophiles.

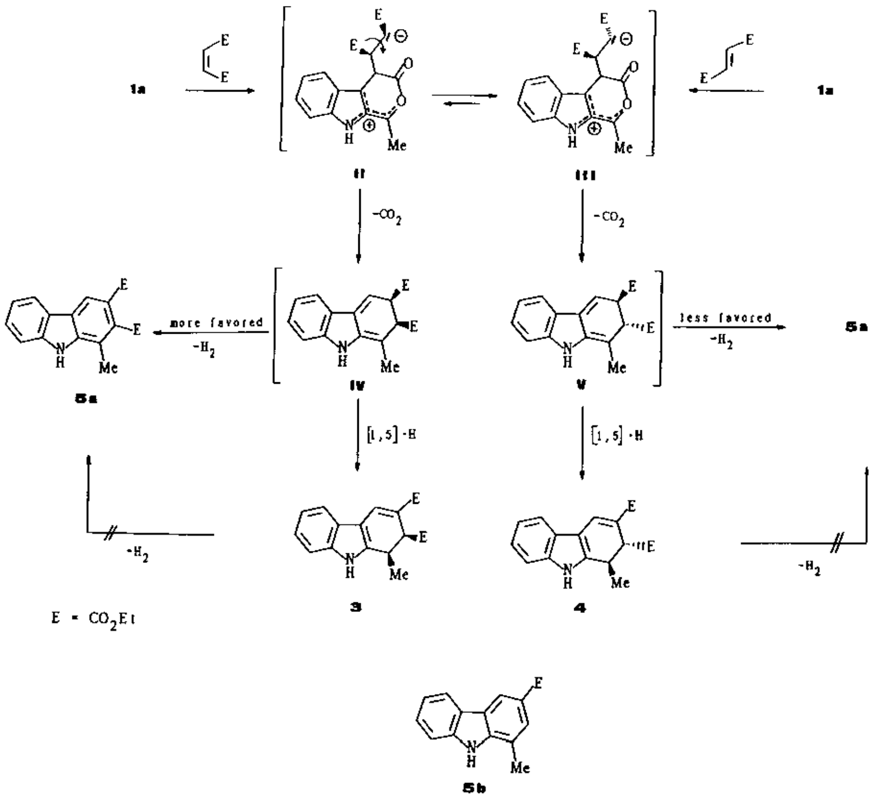


I

1	R
a	H
b	Me

Thus, compound (**1a**) reacts with the analytically pure diethyl (*Z*)- or (*E*)-ethene-1,2-dicarboxylates in a multi-step sequence (comprising [4 + 2]cycloaddition, CO_2-extrusion, sigmatropic [1,5]-H shift, and/or 1,2-elimination) to furnish the stable *cis*- or *trans*-1,2-dihydrocarbazoles (**3**) or (**4**) (Scheme 1, Table 1). In the dihydrocarbazole series, the *trans*-epimer (**4**) is the more stable main product and is obtained from the reactions of **1a** with both the *Z*- and the *E*-dienophile. The fully aromatized carbazoles (**5a**) and (**5b**) were additionally formed from the *Z*- and the *E*-dienophile, respectively (Scheme 1, Table 1). An *E*/*Z*-isomerization of the pure dienophiles under the conditions of the cycloaddition reaction could not be detected by the analytical methods (^{1}H-nmr nOe, tlc, hplc) employed so far. On the basis of a simple product analysis, we suggest that the reaction commences with a non-concerted (two-step) Diels-Alder process. In this case, we assume for the reaction of **1a** with either the *Z*- or the *E*-dienophile that a charge-controlled attack of the (electrophilic) dienophile at the 4-position of the diene moiety in **1a** occurs; this is in full agreement with the high electron and charge densities deduced from the MNDO calculations.[3,4] The resultant zwitterionic (or diradical) intermediates (II)[8] (primarily formed from the reaction with the *Z*-dienophile) and (III) (primarily formed from the reaction with the *E*-dienophile) should equilibrate by a single bond rotation ($\Delta E^{\neq}_{rot} < 3$ kcal/mol) about the carbanionic ethane σ-bond. On the basis of simple steric considerations (Büchi-Dreiding models), interme-

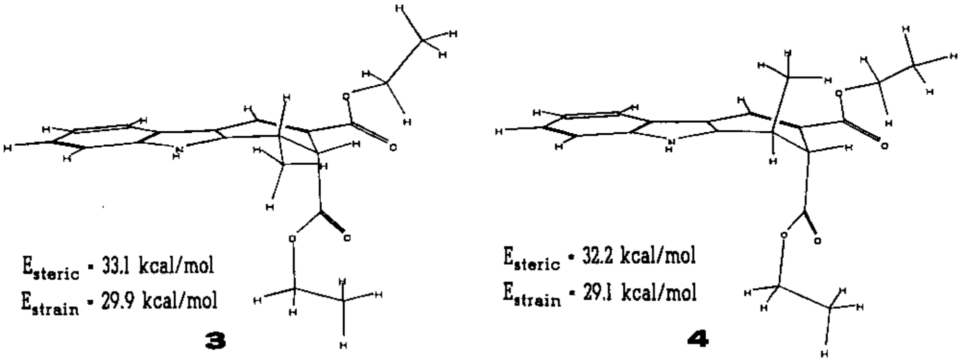
Scheme 1



diate (**III**) should then undergo cyclization more rapidly than **II** to furnish a further bridged intermediate. In general, the stereochemical leakage was greater in the case of the <u>cis</u>-zwitterion (**II**) than of the <u>trans</u>-form (**III**). Extrusion of carbon dioxide[4] from the bridged intermediate should then give rise to the relatively unstable indole-2,3-quinodimethanes (**IV**) and (**V**). These 2,3-dihydrocarbazoles, in turn, undergo stabilization by symmetry-allowed (suprafacial) sigmatropic [1,5]-H shifts towards the C-1 termini, thus yielding the 1,2-dihydrocarbazoles (**3**) and (**4**). From a kinetic point of view, the degree of stereoselectivity generally depends'on the participation of all rate constants. The formation of the carbazole (**5a**) should occur directly from **IV** and **V**. On the other hand, the stereoelectronically controlled cis-H_2 elimination from **IV** must proceed more rapidly since compounds (**3**) and (**4**) are very stable under the reaction conditions (Table 1) and practically no dehydrogenation and no epimerization of these products takes place (^{1}H-nmr monitoring). In addition, the carbazole (**5b**) was formed by formal elimination of HCO_2Et in both cases.

Recently, a related reaction of N-methylated pyrano[3,4-b]indol-3-ones with dimethyl maleate and fumarate was reported[9] but no mechanistic details have yet been made available.

The 400 MHz ^{1}H-nmr spectra of **3** and **4** (DMSO-d_6, 20 °C) reveal that the ring inversion (pseudorotation) of the energetically favored half-chair-like conformation of ring C is restricted. The analysis of the aliphatic ring coupling constants ($^3J_{1,2}$) is in good agreement with the calculated conformers depicted in Figure 1.[10]



E_{steric} = 33.1 kcal/mol
E_{strain} = 29.9 kcal/mol

3

E_{steric} = 32.2 kcal/mol
E_{strain} = 29.1 kcal/mol

4

Figure 1: Energy-minimized conformations of **3** and **4** by MMX molecular mechanics calculations[10] (^{1}H-nmr: **3**, $^3J_{1,2}$ = 8.64 Hz; **4**, $^3J_{1,2}$ = 3.04 Hz).

Some experimental and theoretical results concerning the Diels-Alder reactions of butadienes and related compounds with cyanoethylenes have been reported and non-concerted mechanism were discussed.[7,11,12] However, the methyl-substituted pyrano[3,4-b]indol-3-ones (**1a**) and (**1b**) react with analytically pure fumaric acid dinitrile to furnish the epimeric 1,2-dihydrocarbazoles (**6a**), (**6b**) and (**7a**), (**7b**) (Scheme 2, Table 1). In these cases also, the fully aromatized carbazoles (**8a**) and (**8b**) were formed in addition (2 and 5% yields).

Table 1: Cycloadditions of compounds (**1a**), (**1b**), and (**11**) with 1,2-disubstituted alkenes.

Product	Reaction Conditions[a,b]	Yield[c] [%]	mp[d] [°C]
3	I) 199 mg (1 mmol) **1a**, 3 ml (3.2 g, 16.6 mmol) **A**, 30 ml PhBr, 4 h, 156 °C	I) < 1	–[e]
	II) analogous with 3 ml (3.2 g, 18.3 mmol) **B**	II) 8	
4		I) 16; II) 62	100
5a		I) 52; II) 6	126-128
5b		I) 9; II) 9	143
6a	199 mg (1 mmol) **1a**, 304 mg (3.9 mmol) **C**, 25 ml PhBr, 4.5 h, 156 °C	20	–[e]
7a		40	–[e]
8a		5	255
6b	213 mg (1 mmol) **1b**, 304 mg (3.9 mmol) **C**, 25 ml MeCN, 2 h, 81 °C	21	–[e]
7b		42	–[e]
8b		2	–[e]
9a	199 mg (1 mmol) **1a**, 340 mg (1.1 mmol) **D**, 20 ml PhBr, 5 h, 156 °C	13	262
9b	213 mg (1 mmol) **1b**, 340 mg (1.1 mmol) **D**, 20 ml MeCN, 9 h, 81 °C	15	207
10b		5	265
12	214 mg (1 mmol) **11**, 5 ml (31 mmol) **A** or 5 ml (31 mmol) **B**, 20 ml PhBr, 24 h, 156 °C	9	118-119
13	107 mg (0.5 mmol) **11**, 128 mg (1 mmol) **E**, 10 ml THF, 3 h at 66 °C and 48 h at 20 °C	40	–[e]

[a] **A** = diethyl maleate; **B** = diethyl fumarate; **C** = fumaric acid dinitrile; **D** = 1,2-bis(phenylsulfonyl)ethene; **E** = tetracyanoethylene.

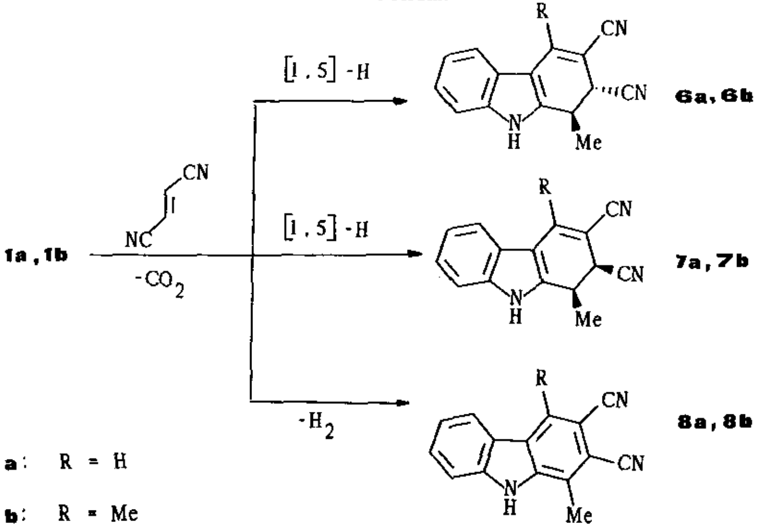
[b] Worked-up by flash chromatography on silica gel (0.040-0.063 mm, Merck), *eluent: petroleum ether* (40-60 °C)/ethyl acetate (8:2).

[c] Yield determined by ^{1}H-nmr spectroscopy. The expected aromatized carbazole (**10a**) (from **1a**) could not be detected by the analytical methods used.

[d] Recrystallized from petroleum ether (40-60 °C)/ethyl acetate.

[e] Isomeric crystalline mixture, separation without decomposition not possible.

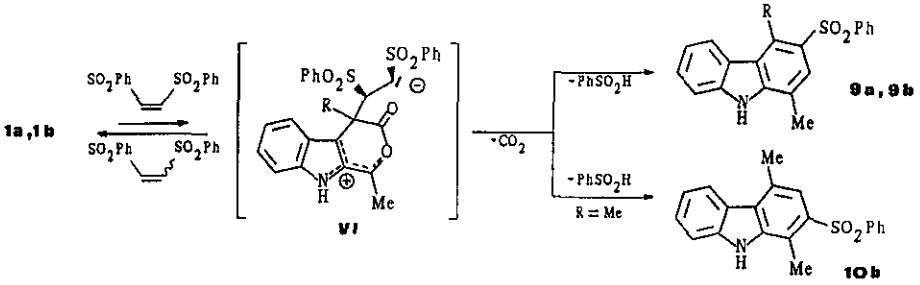
Scheme 2



An isomerization of the E-dienophile under the same reaction conditions but in the absence of **1a** or **1b** was ruled out; also, no epimerizations of **6** and **7** could be detected under these reaction conditions. Hence, for these reactions also, we favor a sequence starting with a non-concerted Diels-Alder reaction, as depicted in Scheme 1, over one starting with a concerted process. According to ^{1}H-nmr spectroscopic analysis, compounds (**6**) and (**7**) in solution are conformationally more flexible with regard to the cyclohexadiene ring moiety than the 1,2-dihydrocarbazoles (**3**) and (**4**). This is a consequence of the smaller steric requirements of the cyano groups in comparison to the ester groups with respect to pseudorotation of the cyclohexadiene ring.

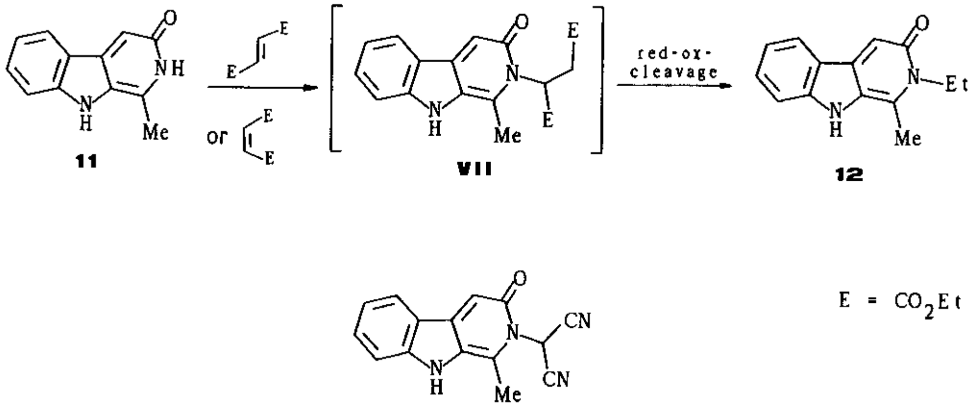
In a further example we have found that compounds (**1**) are able to catalyse a bimolecular E/Z-isomerization of a carbo-dienophile.[13] If any cycloadduct were formed, this would indicate the probable involvement of a non-concerted Diels-Alder process. Thus, **1a** and **1b** reacted with the analytically pure (Z)-1,2-bis(phenylsulfonyl)ethene to give the carbazoles (**9a**), (**9b**), and (**10**) directly by way of a regiospecific elimination of phenylsulfinic acid (Scheme 3), albeit in poor yields (Table 1). The major reaction comprised an isomerization of the employed Z-dienophile to the corresponding E-isomer (E-isomer, yield: 10-35% by ^{1}H-nmr). In the absence of compound (**1**), the Z-isomer is highly stable under the reaction conditions. Hence, we also propose that these reactions begin with the regioselective formation of the betaines (VI) which can equilibrate by rotation about the carbanionic ethane σ-bond, as indicated in Scheme 1. A heterolysis back to the starting materials and hence to the isomerized dienophile does occur and is most certainly more rapid than the next step, the conversion of VI to a bridged cycloadduct.[4] The reaction to the right becomes extremely slow as a result of the steric effects of the relatively bulky SO_2Ph groups on the ring closure process. The enrichment of the E-dienophile in the reaction mixture should thus be the result of a thermodynamically controlled isomerization catalyzed completely by **1**.

Scheme 3



Encouraged by our previous results from the Diels-Alder reactions of 1-methylpyrido[3,4-b]indol-4-one (**11**),[4] we have now investigated its separate reactions with diethyl fumarate and diethyl maleate. Since the primarily formed bridged Diels-Alder adducts were isolable in some cases,[4] we hoped to obtain further experimental proof for the reaction mechanism by analysing the primary product stereochemistry of the bridged bicyclic system.[4] However, **11** only reacted to furnish the N-ethylated derivative (**12**) (Scheme 4). This result is probably a consequence of the high nucleophilicity of the lactam nitrogen atom in **11** which attacks the polarized dienophile in a one-bond process. The resultant intermediate adduct (**VII**) is probably stabilized by a redox-cleavage but no mechanistic details are yet available for this *interesting* "alkylation" reaction.

Scheme 4



11 **VII** **12**

13

On the other hand, the reaction of 11 with tetracyanoethylene proceeded by way of an analogous attack of the dienophile at the nitrogen atom of **11**. However, the resultant N-dicyanomethyl-substituted pyrido[3,4-b]indol-3-one (**13**) was very difficult to purify and has only been characterized by ms and ^{1}H-nmr so far.

The constitutions and configurations of the novel carbazole derivatives obtained were established by physical and spectral data (e.g. ms, ^{1}H-nmr, and, in some cases, by C,H,N-elemental analyses and ^{1}H,^{1}H-nOe measurements).[14] Some of the carbazole derivatives could only be characterized in mixtures (Table 1) since even the use of high resolution chromatographic techniques such as mplc and hplc resulted in decomposition of the products.

In summary, the presented results demonstrate for the first time in pyranoindol-3-one chemistry that, in spite of an optimal $HOMO_{diene}$-$LUMO_{dienophile}$ energy separation (ΔE_{MNDO} = 8-9 eV), a non-concerted Diels-Alder step should preferentially be in operation. (However, the possibility that some molecules can react in a fully concerted manner can never be completely discounted, although this will be extremely difficult to prove). All of our observations support the conclusion that the stabilizing [1,5]-H shift in the 2,3-dihydrocarbazoles occurs stereospecifically in a suprafacial manner.

While our previously reported[2,3] Diels-Alder/cycloreversion sequences of pyranoindol-3-ones with mono-acceptor substituted alkenes and some cyclic (symmetrical) carbodienophiles led first of all to the fully aromatized carbazoles as the main products, the reactions of 1 with E/Z-dienophiles described in the present work additionally give rise to the epimeric 1,2-dihydrocarbazoles. The rationale for this different combination of products can be interpreted as follows. The product distribution should be controlled first of all by the barrier to H_2-elimination from the primarily formed 2,3-dihydrocarbazole intermediate (e.g **IV** and **V** in Scheme 1). In the special case of the cis-2,3-dihydrocarbazole, the stereoelectronically controlled cis-H_2-elimination to give the fully aromatized carbazole is highly favored whereas, in the particular case of the trans-2,3-dihydrocarbazole, the [1,5]-H shift is more favored and the stable 1,2-dihydrocarbazole is formed more rapidly.

REFERENCES AND NOTES

1. C. J. Moody and P. Shah, J. Chem. Soc., Perkin Trans. 1, 1988, 1407; ibid., 1989, 376, and references cited therein.
2. U. Pindur and H. Erfanian-Abdoust, Liebigs Ann. Chem., 1988, 803.
3. U. Pindur and H. Erfanian-Abdoust, Liebigs Ann. Chem., 1989, 227.
4. U. Pindur and H. Erfanian-Abdoust, Heterocycles, 1989, **29**, 11; 1989, ibid., **29**, 1709.
5. Review: U. Pindur and H. Erfånian-Abdoust, Chem. Rev., 1989, **89**, 1681.
6. H. Meier, H.-L. Eckes, H.-P. Niedermann, and H. Kolshorn, Angew. Chem., Int. Ed. Engl., 1987, **26**, 1046.
7. J. Sauer and R. Sustmann, Angew. Chem., Int. Ed. Engl., 1980, **19**, 779.
8. It should be noted that the terms "zwitterionic" and "diradical", when used for describing intermediates, refer to limiting Lewis structures and that the actual intermediates can have varying degrees of zwitterionic or diradical character, depending on the specific system and the experimental conditions. We propose the zwitterion as an attractive intermediate since the indole nucleus is highly capable of stabilizing positive charge while the acceptor-substituted carbanion is extremely stable for similar reasons. For further discussions of intermediates in Diels-Alder reactions, see Ref.[7]
9. P. van Doren, D. Vanderzande, S. Toppet, and G. Hoornaert, Tetrahedron, 1989, **45**, 6761.
10. MMX molecular mechanics program by K. E. Gilbert and J. J. Gajewsky, based on MM2 (Allinger QCPE 395) and MMP1 (Allinger QCPE 318) as modified by K. Steliou (Serena Software, Ltd., Bloomington).
11. M. J. S. Dewar, S. Olivella, and J. J. P. Stewart, J. Am. Chem. Soc., 1986,

108, 5771.

12. R. Sustmann, K. Lücking, G. Kopp, and M. Rese, *Angew. Chem., Int. Ed. Engl.*, 1989, **28**, 1713.
13. Dienophile isomerization in cycloadditions: G. Mloston, E. Langhals, and R. Huisgen, *Tetrahedron*, 1989, **39**, 5373; U. Pindur and M. Eitel, *J. Org. Chem.*, 1990, in press.

14. 400 MHz ^{1}H-nmr data: – (*cis*)-**3** (CD_3CN): δ = 1.12 (t, ^3J = 7.10 Hz, 3H, $CH_2C\underline{H}_3$), 1.28 (t, ^3J = 7.10 Hz, 3H, $CH_2C\underline{H}_3$), 1.46 (d, ^3J = 7.19 Hz, 3H, CH_3), 3.64 (dq, ^3J = 7.09 Hz, ^3J = 8.64 Hz, 1H, 1-H), 3.82 (d, ^3J = 8.64 Hz, 1H, 2-H), 4.00 (m_c, 2H, $C\underline{H}_2CH_3$), 4.18 (m_c, 2H, $C\underline{H}_2CH_3$), 7.12 (m_c, 2H, 6-H and 7-H), 7.39 (m_c, 1H, 8-H), 7.63 (m_c, 1H, 5-H), 7.95 (s, 1H, 4-H), 9.78 (br s, 1H, NH). – (*trans*)-**4** (CD_3CN): δ = 1.12 (t, ^3J = 7.10 Hz, 3H, $CH_2C\underline{H}_3$), 1.21 (t, ^3J = 7.06 Hz, 3H, $C\underline{H}_3$), 1.30 (t, ^3J = 7.16 Hz, 3H, $CH_2C\underline{H}_3$), 3.66 (dq, $^3J_{1,2}$ = 3.04 Hz, ^3J = 7.06 Hz, 1H, 1-H), 3.71 (d, ^3J = 3.04 Hz, 1H, 2-H), 4.01 (m_c, 2H, $C\underline{H}_2CH_3$), 4.21 (2 x q, ^3J = 7.14 Hz, 2H, $C\underline{H}_2CH_3$), 7.13 (m_c, 2H, 6-H and 7-H), 7.38 (m_c, 1H, 8-H), 7.65 (m_c, 1H, 5-H), 7.96 (s, 1H, 4-H), 9.78 (s, 1H, NH). – **5a** (DMSO-d_6): δ = 1.31 (t, ^3J = 7.15 Hz, 3H, $CH_2C\underline{H}_3$), 1.33 (t, ^3J = 7.15 Hz, 3H, $CH_2C\underline{H}_3$), 2.50 (s, 3H, CH_3), 4.29 (q, ^3J = 7.15 Hz, 2H, $C\underline{H}_2CH_3$), 4.33 (q, ^3J = 7.15 Hz, 2H, $C\underline{H}_2CH_3$), 7.24 (dd, ^3J = 7.49 Hz, 7.51 Hz, 1H, 6-H or 7-H), 7.48 (dd, ^3J = 7.20 Hz, 7.54 Hz, 1H, 7-H or 6-H), 7.58 (d, ^3J = 8.09 Hz, 1H, 8-H), 8.26 (d, ^3J = 7.79 Hz, 1H, 5-H), 8.63 (s, 1H, 4-H), 11.82 (s, 1H, NH). – **5b** (CD_3CN): δ = 1.39 (t, ^3J = 7.19 Hz, 3H, $CH_2C\underline{H}_3$), 2.58 (s, 3H, CH_3), 4.35 (q, ^3J = 7.19 Hz, 2H, $C\underline{H}_2CH_3$), 7.25 (ddd, ^4J = 1.00 Hz, ^3J = 7.28 Hz, 7.42 Hz, 1H, 6-H or 7-H), 7.45 (ddd, ^4J = 1.00 Hz, ^3J = 8.25 Hz, 7.03 Hz, 1H, 7-H or 6-H), 7.55 (d, ^3J = 8.18 Hz, 1H, 8-H), 7.89 (d, ^4J = 1.00 Hz, 1H, 2-H), 8.15 (d, ^3J = 7.81 Hz, 1H, 5-H), 8.64 (d, ^4J = 1.00 Hz, 1H, 4-H), 9.69 (s, 1H, NH). – **6a** (CD_3CN): δ = 1.38 (d, ^3J = 7.00 Hz, 3H, CH_3), 3.55 (m_c with quartet habitus, ^3J = 7.78 Hz, 7.62 Hz, 7.43 Hz, 1H, 1-H), 3.81 (dd, ^4J = 1.21 Hz, ^3J = 7.98 Hz, 1H, 2-H), 7.20 (m_c, 2H overlapping with 2H of **7a**, 6-H and 7-H), 7.44 (m_c, 1H overlapping with 1H of **7a**, 8-H), 7.63 (m_c, 1H overlapping with 1H of **7a**, 5-H), 7.81 (s, 1H, 4-H), 9.97 (s, 1H, NH). – **6b** (CD_3CN): δ = 1.33 (d, ^3J = 6.90 Hz, 3H, 1-CH_3), 2.63 (d, ^5J = 1.15 Hz, 3H, 4-CH_3), 3.48 (m_c, 1H overlapping with 1H of **7b**, 1-H), 3.74 (dd, ^5J = 1.15 Hz, ^3J = 6.90 Hz, 1H, 2-H), 7.19 (m_c, 2H overlapping with 2H of **7b**, 6-H and 7-H), 7.49 (m_c, 1H overlapping with 1H of **7b**, 8-H), 7.77 (m_c, 1H overlapping with 1H of **7b**, 4-H), 9.98 (s, 1H, NH). – **7a** (CD_3CN): δ = 1.50 (d, ^3J = 7.05 Hz, 3H, CH_3), 3.59 (m_c with quartet habitus, ^3J = 7.62 Hz, 7.43 Hz, 7.03 Hz, 1H, 1-H), 4.06 (dd, ^4J = 0.73 Hz, ^3J = 6.45 Hz, 1H, 2-H), 7.20 (m_c, 2H overlapping with 2H of **6a**, 6-H and 7-H), 7.44 (m_c, 1H overlapping with 1H of **6a**, 8-H), 7.63 (m_c, 1H overlapping with 1H of **6a**, 5-H), 7.80 (s, 1H, 4-H), 10.03 (s, 1H, NH). – **7b** (CD_3CN): δ = 1.50 (d, ^3J = 7.00 Hz, 3H, 1-CH_3), 2.61 (d, ^5J

= 1.00 Hz, 3H, 4-CH$_3$), 3.48 (m$_c$, 1H overlapping with 1H of **6b**, 1-H), 3.97 (dd, $^5\underline{J}$ = 1.00 Hz, $^3\underline{J}$ = 7.00 Hz, 1H, 2-H), 7.19 (m$_c$, 2H overlapping with 2H of **6b**, 6-H and 7-H), 7.46 (m$_c$, 1H overlapping with 1H of **6b**, 8-H), 7.77 (m$_c$, 1H overlapping with 1H of **6b**, 4-H), 10.06 (s, 1H, NH). - **8a** (CD$_3$CN): δ = 2.71 (s, 3H, CH$_3$), 7.34 (ddd, $^4\underline{J}$ = 1.60 Hz, $^3\underline{J}$ = 7.23 Hz, 7.27 Hz, 1H, 6-H or 7-H), 7.58 (ddd, $^4\underline{J}$ = 1.00 Hz, $^3\underline{J}$ = 8.23 Hz, 7.95 Hz, 1H, 7-H or 6-H), 7.61 (d, $^3\underline{J}$ = 8.23 Hz, 1H, 8-H), 8.12 (d, $^3\underline{J}$ = 7.89 Hz, 1H, 5-H), 8.44 (s, 1H, 4-H), 10.20 (s, 1H, NH). - **8b** (CD$_3$CN): δ = 2.72 (s, 3H, 1-CH$_3$), 3.01 (s, 3H, 4-CH$_3$), 7.38 (dd, $^3\underline{J}$ = 7.80 Hz, 7.25 Hz, 1H, 6-H or 7-H), 7.60 (dd, $^3\underline{J}$ = 6.99 Hz, 7.67 Hz, 1H, 7-H or 6-H), 7.68 (d, $^3\underline{J}$ = 8.09 Hz, 1H, 8-H), 8.27 (d, $^3\underline{J}$ = 7.79 Hz, 1H, 5-H), 10.44 (s, 1H, NH). - **9a** (DMSO-$\underline{d}_6$): δ = 2.59 (s, 3H, CH$_3$), 7.24 (dd, $^3\underline{J}$ = 7.36 Hz, 7.45 Hz, 1H, 6-H or 7-H), 7.47 (dd, $^3\underline{J}$ = 7.79 Hz, 7.26 Hz, 1H, 7-H or 6-H), 7.58 (m$_c$, 4H, 3'-H, 4'-H, 5'-H, and 8-H), 7.74 (s, 1H, 2-H), 7.98 (d, $^3\underline{J}$ = 6.85 Hz, 2H, 2'-H and 6'-H), 8.29 (d, $^3\underline{J}$ = 8.30 Hz, 1H, 5-H), 8.67 (s, 1H, 4-H), 11.80 (s, 3H, NH). - **9b** (CD$_3$CN): δ = 2.61 (s, 3H, 1-CH$_3$), 2.92 (s, 3H, 4-CH$_3$), 7.23 (ddd, $^4\underline{J}$ = 1.00 Hz, $^3\underline{J}$ = 8.09 Hz, 7.17 Hz, 1H, 6-H or 7-H), 7.45 (ddd, $^4\underline{J}$ = 1.00 Hz, $^3\underline{J}$ = 7.69 Hz, 7.67 Hz, 1H, 7-H or 6-H), 7.54 (m$_c$, 4H, 3'-H, 4'-H, 5'-H, and 8-H), 7.86 (dd, $^4\underline{J}$ = 1.30 Hz, $^3\underline{J}$ = 8.30 Hz, 2H, 2'-H and 6'-H), 8.09 (s, 1H, 2-H), 8.14 (d, $^3\underline{J}$ = 8.06 Hz, 1H, 5-H), 9.80 (s, 1H, NH). - **10b** (CD$_3$CN): δ = 2.63 (s, 3H, 1-CH$_3$), 2.91 (s, 3H, 4-CH$_3$), 7.27 (ddd, $^4\underline{J}$ = 1.00 Hz, $^3\underline{J}$ = 8.05 Hz, 7.13 Hz, 1H, 6-H or 7-H), 7.49 (ddd, $^4\underline{J}$ = 1.02 Hz, $^3\underline{J}$ = 7.71 Hz, 7.65 Hz, 1H, 7-H or 6-H), 7.58 (m$_c$, 4H, 3'-H, 4'-H, 5'-H, and 8-H), 7.81 (s, 1H, 3-H), 7.88 (dd, $^4\underline{J}$ = 1.50 Hz, $^3\underline{J}$ = 8.00 Hz, 2H, 2'-H and 6'-H), 8.22 (d, $^3\underline{J}$ = 8.03 Hz, 1H, 5-H), 9.67 (s, 1H, NH). - **12** (CD$_3$CN): δ = 1.37 (t, $^3\underline{J}$ = 7.04 Hz, 3H, $CH_2C\underline{H}_3$), 2.64 (s, 3H, CH$_3$), 4.32 (q, $^3\underline{J}$ = 7.04 Hz, 2H, $C\underline{H}_2CH_3$), 7.17 (m$_c$, 2H), 7.49 (m$_c$, 2H), 8.05 (d, $^3\underline{J}$ = 7.74 Hz, 1H, 5-H), 9.25 (s, 1H, NH). - **13** (DMSO-$\underline{d}_6$): δ = 3.38 (s, 3H, CH$_3$), 7.40 (dd, $^3\underline{J}$ = 7.72 Hz, 7.69 Hz, 1H, 6-H or 7-H), 7.58 (s, 1H, 4-H), 7.69 (d, $^3\underline{J}$ = 8.21 Hz, 1H, 8-H), 7.81 (dd, $^3\underline{J}$ = 7.53 Hz, 7.89 Hz, 1H, 7-H or 6-H), 8.44 (d, $^3\underline{J}$ = 7.28 Hz, 1H, 5-H), 8.89 (s, 1H, $C\underline{H}(CN)_2$), 12.41 (s, 1H, NH).

Received, 23rd July, 1990